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Towards reduced uncertainty in catchment nitrogen modelling: quantifying the effect of field observation uncertainty on model calibration

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Abstract. The value of nitrogen (N) field measurements for the calibration of parameters of the INCA nitrogen in catchment model is explored and quantified. A virtual catchment was designed by running INCA with a known set of parameters, and field "measurements" were selected from the model run output. Then, using these measurements and the Shuffled Complex Evolution Metropolis algorithm (SCEM-UA), four of the INCA model parameters describing N transformations in the soil were optimised, while the measurement uncertainty was increased in subsequent steps. Considering measurement uncertainty typical for N field studies, none of the synthesised datasets contained sufficient information to identify the model parameters with a reasonable degree of confidence. Parameter equifinality occurred, leading to considerable uncertainty in model parameter values and in modelled N concentrations and fluxes. Fortunately, combining the datasets in a multi-objective calibration was found to be effective in dealing with these equifinality problems. With the right choice of calibration measurements, multi-objective calibrations resulted in lower parameter uncertainty. The methodology applied in this study, using a virtual catchment free of model errors, is proposed as a useful tool foregoing the application of a N model or the design of a N monitoring program. For an already gauged catchment, a virtual study can provide a point of reference for the minimum uncertainty associated with a model application. When setting up a monitoring program, it can help to decide what and when to measure. Numerical experiments indicate that for a forested, N-saturated catchment, a fortnightly sampling of NO_3 and NH_4 concentrations in stream water may be the most cost-effective monitoring strategy.

Keywords: INCA, nitrogen model, parameter uncertainty, multi-objective calibration, virtual catchment, experimental design

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